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[Proceedings continued from page 176.]

11. *On the* Geology *of the* North-east part *of the* Dobrutcha. By T. Spratt, Captain R.N., F.R.S., F.G.S.

Having had an opportunity, during the latter part of last year, of extending my geological inquiries in the eastern part of the Dobrutcha, and of obtaining a better idea of some parts of its character, I am induced to offer a few remarks as a continuation of my former paper on this locality*.

It is known that the northern extremity of the Dobrutcha is terminated by a chain of mountains that obtain an elevation of between 1000 and 2000 feet. They consist of highly-inclined limestones, shales, and schistose rocks. But the bold features usually assumed by the description and elevation of rocks of this nature are generally subdued here by their flanks and shoulders being covered by a considerable deposit of arenaceous marls, of reddish, grey, and brown colours. The marls are undoubtedly of a late date; but their origin I am not able to determine, from the total absence of fossils wherever examined by me.

In this remark I allude especially to the group of superficial, earthy or arenaceous, red and brownish marls of the Steppe, inseparable from the known freshwater marls; for I have recently

* See Quart. Journ. Geol. Soc. vol. xiii. p. 77.

ascertained that the former are not a continuation of the lower fresh-water deposits which I have already noticed at Kustenjeh, and as I once supposed.

I shall commence my remarks at the north end of the Dobrutcha by simply referring to the existence of these older rocks at Isatchka, Tultcha, and Besh Tepeh on the Danube; and, although some appear to be metamorphic from volcanic agency, they are no doubt of an early age; perhaps either Devonian or Carboniferous.

The only place where rocks of a similar age appear on the shores of the Black Sea, in the Dobrutcha, is at Kara Irman, near Cape Media. At this spot, which is near the south-west corner of the Raselm Lagoon, and where the delta of the Danube commences, there are dark shales of considerable thickness, and much resembling the shales and schistose strata occurring on the flanks and base of the Balkan, near Cape Emeneh.

The section (fig. 1, p. 206) of the coast-cliff, from Kara Irman towards Cape Media, is of much interest, from the contact of a limestone of Secondary age with these older shales; both being overlaid by the superficial, reddish-brown, earthy marls of the Steppe, without any intermediate group.

The dark shales and schists, *a*, of fully 500 or 600 feet in thickness, form a portion of the rocky shore at Kara Irman, at the angle of the coast, where a ridge of the Steppe projects into the Black Sea as a small promontory, and acts as a natural groyne to hold in check the alluvial deposits of the Danube. At this point there was formerly a scala, or landing-place, for communication with the villages of the neighbourhood, and the ancient town of Istia seems also to have been near here.

These dark shales dip to the northward, at an angle of 40°, the strike being S. 83° W.; and, although appearing along the coast for about a quarter of a mile, they are nowhere more than 3 or 4 feet above the sea, and are immediately overlaid by about 40 feet of the soft, reddish-brown, earthy marls of the superficial series of deposits, *e*. I had no opportunity of examining them minutely in search of fossils.

The cliffs of white compact limestone, b_1, contain corals and marine shells; they are only from 16 to 20 feet high. The beds lie nearly horizontally, and seem to have been originally deposited against the older shales; but they may have been thus brought in contact by a fault.

These limestones are shattered, and filled with small cavities, especially where the fossils are most abundant. A *Rhynchonella* seems to be the characteristic fossil.

The second mass of limestone, b_2, is a coast-cliff about one mile nearer Cape Media *; and the compact white limestone of which it is

* The specimens from Cape Media, forwarded to the Society by the author, consist of yellowish, cream-coloured, and grey limestones (hard and crystalline) with *Pectines*, *Terebratulæ*, *Rhynchonellæ*, a univalve, and Corals.

Some hard, yellowish, and grey limestones, sent by Capt. Spratt from Lake Raselm, much resemble those of Cape Media, and contain remains of *Ammonites*

composed, although identical in mineral character with the first mass, in contact with the shales, is less fossiliferous and more distinctly stratified.

Both these masses are overlaid by about 2 feet of rubbly white marl (omitted in the Section), succeeded by the reddish-brown marls *e, e,* which are not more than 20 feet thick over the limestones; but are fully 40 and 50 feet thick in the intermediate spaces. As none of the *identified* freshwater marls cap these limestones, but only such as are of a doubtful age and origin, possibly connected with a disturbed or changing condition in the later period of the freshwater series, these limestones must have stood as ridges, rocks, or islets, when the freshwater lake, which I believe once covered the area of the Black Sea and Archipelago together, existed, and of which the lower deposits south of Kustenjeh, and the upper at Baljik, 400 feet above it, give some positive indications, as also, I think, the freshwater limestones or marls of Odessa and Kertch.

Between Cape Media and Kustenjeh is a freshwater lake, about 4 miles long and 2 broad. It is separated from the sea by a strip of sandhills, which extend between the extremities of two ridges of the Steppe, and terminate in a cliff at the south, towards Kustenjeh.

The inner shores of the lake are for the most part chalky cliffs, or marly banks, that were, without doubt, the sea-margin at some early period; so that this freshwater lake has been formed out of a small arm of the sea, by means of the alluvial sand having been moved along the coast from the Danube (by the prevailing winds and currents), and thus accumulated in nearly a direct line across the mouth of the bay. From the existing copious springs of fresh water on the shore of the bay, the enclosed arm of the sea, or salt lagoon, has become a freshwater lake. The bay was also originally a deep-water inlet of the Black Sea, since it has now a depth of 18 or 20 feet nearly all over the lake.

The north-west shore of the lake is chiefly low banks of brown marl, belonging to the superficial series. But the south-west shore presents geological features of considerable interest, more particularly between the villages of Kanara and Pallas *.

At about half a mile from the former village is a small islet covered by a grove of trees; but the islet is not more than 4 or 5 feet above the sea. Of this islet 2 or 3 feet is a rich soil, and the base a mass of inclined strata of compact cream-coloured limestone, much resembling that which I have noticed at Cape Media.

(*Ceratites* ?), *Pectines*, *Terebratulæ*, *Rhynchonellæ*, *Modiola*, a small Echinoderm, fragments of Crinoidal stems, and Corals. A somewhat similar cream-coloured compact limestone, sent by Capt. Spratt from Cape Karabournou, Roumelia, contains fragments of *Ostræa*, *Lima*, *Terebratula*, Corals, a fragment of a Crustacean, and casts of univalves and bivalves. A softish buff-coloured laminated limestone from Cape Dolashma, Lake Raselm, contains numerous small *Inocerami* in layers, and branching fucoidal bodies.—Edit.

* These localities are shown on the map illustrating Capt. Spratt's "Route between Kustenjé and the Danube," published in the 'Journal of the Royal Geographical Society,' vol. xxvi.—Edit.

Fig. 1.—*Section of the Eastern Coast of Cape Media.*

e, e. Brownish marls of the "superficial series." b_1, b_2. Fossiliferous limestone of Secondary age. *a.* Old schists.
(The rubbly and chalky marl, overlying *b, b,* is omitted.)

Fig. 2.—*Section of the South-west Coast of Kanara Lake, near Kustenjeh.*

b_1. Limestone and shale of Secondary age. b_2, b_3, b_4. Chalk and chalk-marl. *c, c.* Sandstone of Tertiary age.
e, e. Reddish marls of the "superficial series."

Fig. 3.—*Section at Kustenjeh.*

c. Older Tertiary shelly limestone. *d.* Freshwater deposits (50 feet). *e.* Reddish marls of the Steppe (100 feet).

A rocky point, which juts into the lake to the east of Kanara, seems also to be a part of the same limestone.

The opposite section, fig. 2, will explain the disposition of the formations :—

A cream-coloured compact limestone, b_1, interstratified with light-grey shales, in layers from 1 to 3 feet thick, together attaining a thickness of 500 or 600 feet, occupies the point; and at the extremity the strata dip to the S.W. by S., or S.W., at an angle of 35°. Here they are more crystalline than at 200 or 300 yards within the point; this indicates, perhaps, a proximate igneous rock not visible.

The dip of the strata diminishes as they recede from the point towards the village of Kanara, where they seem to be in contact with, and overlaid by, white chalky marl, b_2; but whether passing into and conformable with it, I could not ascertain, on account of the superficial marls of the Steppe, *e*, covering the whole.

Although I procured no fossils from the limestones, b_1, at Kanara Point or at the island, the beds seemed to be identical in mineralogical character with those at Cape Media, fig. 1; more particularly as the chalk-marls overlie them in apparent continuity of succession. The chalk-marls* appear, by the fossils that I procured from them, to be either of the Cretaceous or Upper Jurassic age.

About half a mile to the south-east of the village of Kanara rises a semicircular cliff of the chalk-marl, nearly 30 feet high (b_3, in the section, fig. 2). The chalk-marl dips to the south-east or southward, at from 5° to 8°, and is capped by about 15 feet of yellowish-brown sandstone, *c*, with oolitic rock. This appears to be an early tertiary deposit, and corresponds with some oolitic strata that occur at the base of Kustenjeh Point (see *c*, fig. 3), as also with the oolitic strata of the Malakoff ridge at Sevastopol.

The deposit, *c*, capping the chalk, is unconformable, and is evidently of an early Tertiary age †.

This chalk-cliff must have been an elevated point in the fresh-water lake of the Tertiary period, since it is covered and flanked only by the superficial marls of the Steppe series (*e* in both the sections). These also fill the valleys on either side of the ridge.

At about half a mile more to the south-east is another chalk-cliff, b_4, which extends along the coast for more than a mile, and beyond the village of Pallas. This cliff seems to be composed of an upper series of the Chalk, since the strata have the same dip as in the former section, and contain a large quantity of siliceous bands and nodules, though very few fossils. I could procure only a few fragments, as the whole series of strata composing this cliff are more indurated than in the chalk at Kanara.

* Portions of a Ventriculite, together with ferruginous ramose concretions and pyritous balls, are in the specimens of this soft white calcareous rock, sent by the author. It contains also cretaceous Foraminifera.—Edit.

† Specimens sent to the Society are—a hard oolitic white limestone with bivalves (*Lucina* ?); a cream-coloured compact crystalline limestone; and a hard yellowish limestone, full of casts of univalves and bivalves, chiefly two forms of fluted *Cardium* or *Adacna*.—Edit.

This cliff is also capped by about 10 feet of rubbly oolitic sandstone, *c*, like that at the cliff near Kanara, and containing similar fossils. If this, as I conjecture, be an Eocene bed, it is here a mere remnant of that group.

The chalk-cliffs gradually decrease in elevation from the village of Kanara, and altogether disappear a little beyond Pallas, where the superficial red marls replace them, and form the sea-cliffs to Kustenjeh.

This group of marls, of the superficial series, are well developed in the cliffs both to the north and south of Kustenjeh. To the north of it, the cliffs are more than 100 feet high, and entirely composed of these marls. Some of the strata are dark umber-brown, and contain nodules of soft chalk, also bands and crystals of gypsum; but there are no gravels—no indication here of their having been deposited in waters under any *violent* movement. To this the soft chalk-nodules are the only exception, showing probably an agitation or current, and appear to have been derived from the proximate chalk-deposits, before described. But I saw no heavy nodules of indurated chalk, or of chalk-flint, such as would indicate any violent aqueous movement. These deposits, filling up the denuded hollows and valleys which existed on the surface of the Cretaceous and early Tertiary ridges, are destitute of fossils, and seem to be due to a rapid deposition from highly-charged waters. And this also seems to be indicated by the absence of such a uniform and constant series of strata as may be expected to occur in slowly-formed deposits.

When I partially described the Kustenjeh marls*, I was not able to separate them into two distinct groups. But further researches more to the south have enabled me to discover that the probably freshwater deposits of the lower series, in which I procured a fragment of an Elephant's tusk, and some casts of a Cyclas-like bivalve, do not pass into the overlying series of reddish-brown marls.

My conjecture of the freshwater origin of the lower portion of the deposits to the south of Kustenjeh is confirmed by my discovering more terrestrial and probably freshwater-shells in them; and thus they are identified with the upper series of freshwater deposits, which I have noticed as covering a fragment of the early Tertiary at Baljik†, where they are more than 100 feet in thickness, and 500 feet above the sea. But at Kustenjeh they are only observed at the sea-level, and from 30 to 40 feet above it.

I therefore take this opportunity of correcting my former section of the Kustenjeh deposits by the one given at p. 209, with fuller details.

The lowest bed is about 5 feet of yellowish-white oolitic limestone, *c*, fig. 4, with marine fossils. This is apparently of the Eocene age, and much resembles the oolitic rocks near Varna‡ and Sevastopol. The

* Quart. Journ. Geol. Soc. vol. xiii. p. 78.

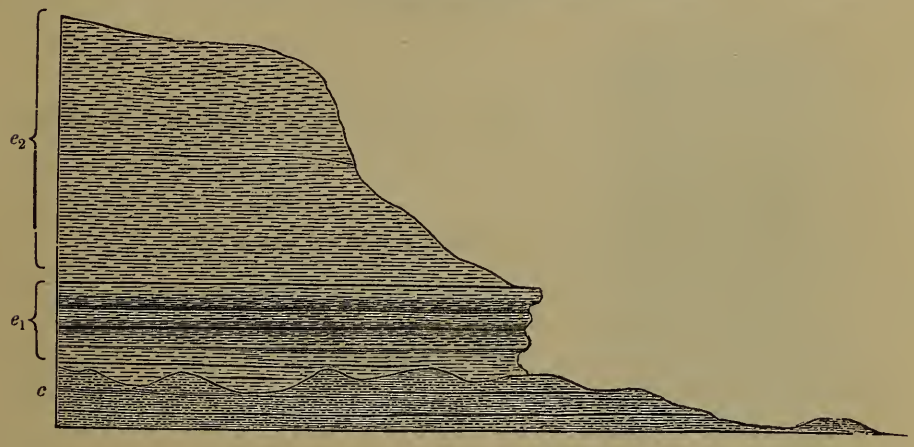
† *Loc. cit.* p. 77.

‡ In the opinion of M. Abich, For. Mem. G. S., who has carefully examined the fossils from the neighbourhood of Varna, these deposits are of Miocene age.—Ed. Q. J. G. S.

dip of the strata is apparently to the N.E., at an angle of 8° or 10°.

In examining minutely the deposits forming the Point of Kustenjeh, I found that this rock terminates abruptly on the north and south sides of the promontory, as if by a fault; and it is overlaid by deposits that seem to belong only to the red marls or superficial series, *e*, although the lower bed, immediately reposing on *c*, contains casts of a *Cyrena*? similar to what are found in the upper portion of the group *d*, fig. 3, where the beds and fossils indicate no such evidence of having been aggregated by moving waters.

Fig. 4.—*Section of Kustenjeh Point.*



e_2. Reddish marls. e_1. Shelly sandstones, 7 feet thick.
c. Older Tertiary oolitic limestone, marine.

On the older tertiary deposit, *c*, is a thinly stratified yellowish sandstone, e_1, 7 feet thick, and composed almost entirely of fragments of shells and oolitic particles. In it are bands and masses of casts of *Cyrenæ*? like those found in group *d*, figs. 3 & 5.

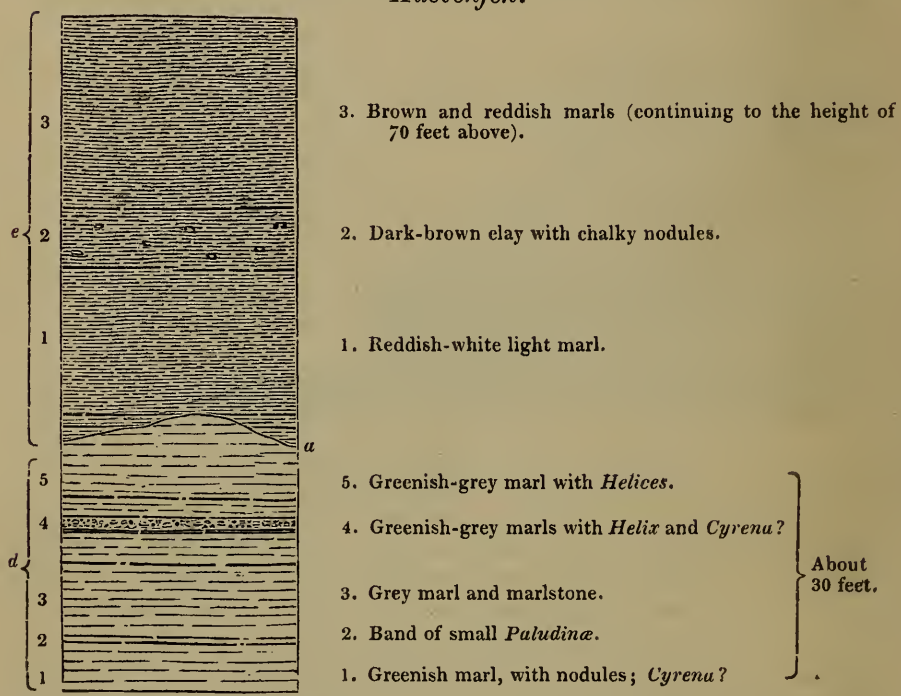
This deposit, e_1, from containing the oolitic grains and these bivalves, seems to be composed of the debris of groups *c* and *d*, under a sudden disturbance of the old lake, in which the rock *c* formed perhaps an islet or shoal during its previous tranquil condition.

The next bed, e_2, is about 30 feet of red marl or clay, without any indication of fossils or foreign fragments, and is a small portion of the superficial marls, *e*, of the Steppe, which I shall have to refer to in describing more particularly the evidence of the separation between the marls *d* and *e* of fig. 3.

This will perhaps be best done by giving a section (fig. 5) of a part of the cliff at about half a mile S.W. of Kustenjeh, where a fresh landslip or scaling showed me clearly the point of separation between the two series of marls, marked by the denudation of a portion of the lower group, as seen at *a*, and the subsequent filling up of the irregularities by the upper red marl series. This separation is difficult to identify where the upper series reposes upon a more indurated stratum of the freshwater series, as frequently occurs.

When both lie nearly horizontal, they appear to be conformable, as in the cliff about one mile south of Kustenjeh. Here I saw, in ascending order, 1st, 10 feet of a greenish-grey marl, with indurated nodules of marlstone, and sometimes chalky nodules, but not derived apparently from any foreign locality; also crystals of gypsum, and casts of a *Cyclas* or *Cyrena*; 2nd, an indurated band, from 2 inches to 1 foot thick, filled with casts of a small *Paludina*; 3rd, 5 or 6 feet of grey marl, with bands of marlstone; 4th, 20 feet of greenish-grey marls, with broken layers of marlstone, forming slabs and nodules, in which are found casts of a bivalve (*Cylas*?), also an occasional

Fig. 5.—*Section of part of the Cliff half a mile South-west of Kustenjeh.*



Helix, similar to the one found in the freshwater deposits over Baljik*; 5th, a more indurated stratum of the greenish-grey marls, from 2 to 3 feet thick, and replete with *Helices*. This is also sometimes pisolitic, and its indurated character is evidently due to the aggregation of the fossils. The shells, probably, were not accumulated by any violent action of the waters from currents or drift, but lived at the bottom during a late period of the lake, when it seems to have been very shallow, and perhaps, in consequence, subject to stronger superficial currents, from local winds and local torrents. Hence the associated land-shells and lacustrine shells were thus mingled together in accidental groups; as no doubt must occur often at the bottom of shallow tideless waters proximate to land prolific with vegetation and land-shells. This condition must have existed on the old chalk-ridges that formerly bordered the lake not far from these

* Quart. Journ. Geol. Soc. vol. xiii. p. 77.

cliffs, as I have shown previously. Chalky downs are always highly favourable to the prolific development of land-shells, as is well known to all naturalists. And I digress for a moment to suggest that, in this view, we have an explanation also of the origin of the white marly character and great thickness of the Baljik freshwater deposits, as having been derived from the denudation of these great chalky ridges by the torrents of every season's rain. Here also the land-shells (*Helix*) are as abundant in the upper series of the deposits as the bivalves and other freshwater shells that lived in the lake.

Referring to the section, I have to add that the fossiliferous bands of the lower freshwater series thin out sometimes to a thickness of a few inches at distances of a few hundred yards on either side: such is the case towards Kustenjeh, where, being less indurated, they have been superficially denuded, as shown in fig. 5, *a*.

At the locality where the last-described section was taken, however, the greenish marls present a flat surface, upon which immediately succeed the reddish marls of the upper series, which I have before described as being stratified in thick beds of dark-brown, grey, or reddish marls; they are nearly 100 feet thick in some parts. The upper marls are lighter and somewhat porous *.

In closing my remarks, I shall merely state that I have no doubt but that the continuity of the Kustenjeh freshwater deposits will be traced hereafter up to the elevated deposits of Baljik, as a continuation of the bottom of the same lake. And I venture to suggest that they are also identical with those of Odessa and Kertch, neither of which, however, I have had an opportunity of examining. Their connexion is to my mind also certain with those of the shores of the Sea of Marmora, by the valley of Brujuk Tchekmijeh, where I some time since found freshwater fossils in its deposits, together with a band of lignite. Also the lignite and gravel-beds examined by Mr. H. Poole† on the south side of the Sea of Marmora, near Brusa and Ismid, I believe to be of freshwater origin; and I connect them as indications of one great eastern freshwater lake that existed perhaps from the Miocene to a late Tertiary period. The actual limits of this lake westward as well as eastward have yet to be defined by

* The specimens from the "Upper series of the Steppe deposits," sent to the Society, comprise—1. red marl; 2. soft, yellow, laminated, argillaceous sandstone; 3. brownish, sandy, micaceous marl; 4. a brownish marl, like No. 3, but altered by atmospheric agency, perforated with minute irregular tubules (as is also No. 3), and containing small, soft, calcareous concretions; 5. like No. 4, but less calcareous, and redder; also buff- and salmon-coloured calcareous concretions, and soft white marl.

The specimens of the "Freshwater series" comprise—1. shelly, cream-coloured, compact limestone, full of casts of *Helices* and a *Bulimus*; 2. hard, grey, shelly limestone (weathered), concretionary or oolitic, and crystalline, full of casts of bivalves (*Cyrena*?), and containing a few casts of small univalves; 3. marly limestone, full of casts of *Cyrena*?, passing into a hard, grey crystalline limestone, with similar casts, and resembling No. 2; 4. greyish limestone, full of casts of *Cyrena*?, interior of the casts sometimes oolitic; 5. grey limestone, full of hollow black moulds of a small *Paludina*; 6. green clay, with a portion of an elephant's tusk.—Edit.

† Quart. Journ. Geol. Soc. vol. xii. p. 1, &c.

determining the precise age of the great volcanic centres, that, from Ararat to Lemnos, and Santorin to Vesuvius, have from time to time uplifted or submerged parts of its expansive bed.

In merely touching upon this view, I am induced to recall to mind the other isolated fragments of freshwater deposits that occur in Rhodes, Crete, Cerigo, and in the western basin of the Mediterranean, of Provence, Lombardy, Florence, Minorca, &c., as reviving an old idea of a chain of lakes having existed in the Mediterranean basin during this period, or rather during a portion of it.

In the sections here given it will be seen, that the superficial red earthy marls of the Steppe-series cover rocks of all ages, and that the freshwater marls, *d*, are often wanting. The probable explanation is, if the former were deposited in freshwater also, that the old land surrounding the lake became suddenly submerged at the commencement of this red marl series,—or that the level of the lake became suddenly raised by the escape of water from some more extensive and more elevated basin,—or that the waters were suddenly raised, having been pent up within more limited bounds, on account of the rising of some great mass of continent, such as a large part of Asia Minor, from out of the great eastern freshwater basin which I suppose to have existed.

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12. *On the* Freshwater Deposits *of the* Levant.

By T. Spratt, Captain R.N., F.R.S., F.G.S.

The brief account recently published* of the extensive freshwater deposits which exist on the western shores of the Grecian Archipelago calls for a notice of those within my knowledge on the eastern shores.

The freshwater tertiaries of Smyrna and Scio† have been traced by me as fragments along the eastern and southern coasts of Mitylene, as well as on the coasts opposite,—the detached and disturbed condition of these deposits being due to extensive outbursts of igneous rocks that form large districts within this island and on the main land opposite to it. For instance, the Moskonisi and Aivali districts, the Assos Range to Cape Baba, Touzla, and Alexandria-Troas, and, in Mitylene, the north-eastern part of the island, including Mount Lepethimus, as well as the entire peninsula west of Port Kelloni, are composed of volcanic rocks. Besides these there are several lesser protrusions of trap in numerous parts of the intermediate districts.

The vicinity of Mitylene presents an interesting association of the trap and the freshwater deposits, particularly to the south, as shown in the following section, fig. 1.

At Cape Vourkas we meet with the trap and tertiary strata in proximity, particularly on the east short of Port Kelloni, while the white freshwater marls are nearly vertical, and contain several specimens of a small *Helix*.

* Quart. Journ. Geol. Soc. vol. xiii. p. 177.

† Described in the Society's Quarterly Journal, vol. i. p. 156.

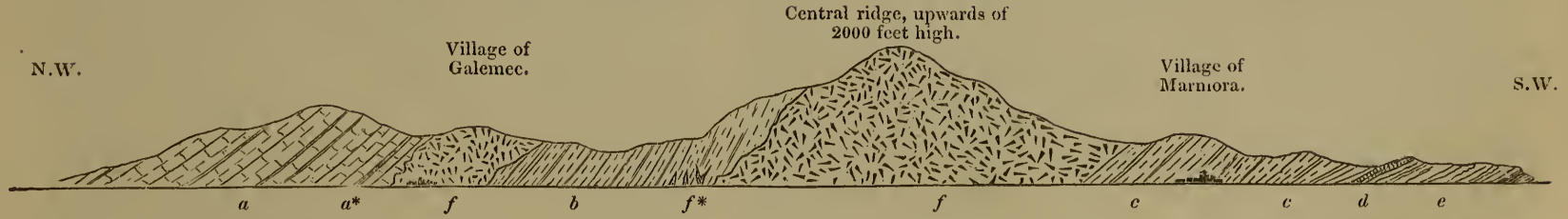
Fig. 1.—*Section of a part of the Island of Mitylene.*

a. Grey sands and marl. *b*. Yellowish arenaceous limestone and marl. *c*. White and variegated strata. *d*. White and brown strata. *e*. Limestones. *f*, *f*. Igneous rocks.

Fig. 2.—*Section of the Island of Tenedos.*

a. White arenaceous limestone, 40 feet thick, fossiliferous. *b*. White sandy marl, containing Oysters and Pectens. *c*. White compact limestone, full of casts of a *Cyrena*? *d*. White, brown, grey, and black marls, marlstone, and sandstone, highly fossiliferous in some parts. *f*. Limestones, of Secondary age, reaching a height of about 100 feet.

Fig. 4.—*Section along the West Coast of the Island of Marmora.* (See p. 218.)



a. Veined marble, interstratified with shale. *a**. White crystalline limestone, shown in a newly-opened quarry. *b*. Dark-green shales; dip 50° to N.E. *c*, *c*. Dark-grey and blue shales. *d*. Limestone. *e*. Contorted micaceous shales, dark-brown and green; dip 30° to N. *f*, *f*. Intrusive porphyritic granite. *f**. Veins of granite, in the vertical and crystalline schists, near Steelan Monastery.

The Island of Tenedos is still more interesting and instructive in respect to the relative position of the freshwater deposits, and for their greater development, as seen in fig. 2, p. 213.

Here the freshwater deposits are found to be capped by about 40 feet of a white arenaceous limestone, containing marine shells of the present sea, both deposits lying nearly horizontal, and apparently conformable. The exact place of separation of these two groups is not easy to be detected; and it was some time before I discovered positive proof of the freshwater origin of the lower group of strata, *c* and *d* in the section.

Three-fourths of the island is comprised of these horizontal beds of freshwater and marine tertiaries, which together are fully 100 feet thick. The other fourth consists of a conical peak of trachyte (Mount Elias), rising like a dome over the extreme north-east cape of the island, and throwing off from its southern flanks ridges of secondary limestones and shales, somewhat frizzled by the contact; these are succeeded or overlaid by horizontal strata of the Tertiary series, as shown in fig. 2.

The fossils which I procured from the bed *d* are a small *Paludina*, *Planorbis*, *Neritina*, *Cyrena* (?), *Melanopsis*, and a ribbed bivalve (*Cardium*) similar to the one found in the Dardanelles deposits near Meitos and over Nagara Point.

The deposit *a* contains shells similar to those of the present sea; and, although they are upwards of 100 feet above the sea-level, they are apparently of a late Tertiary age (older or newer Pliocene), like the marine deposits which repose against the freshwater beds at the south-east extremity of the island of Cos.

To the north of Cape Baba, near the River Touzla, there are some coast-cliffs of this late marine tertiary, from 30 to 40 feet high, in which the beds seem to repose on the adjacent igneous rocks. The latter extend northward to the mountains at the back of Alexandria-Troas, where a granitic trap predominates, and from whence columns, in early days, and stone-shot for the guns of the Dardanelles, in later times, have been quarried. These quarries occur near the village of Chimali.

More to the northward, the blue semi-crystalline limestone and shales of the secondary group of rocks replace the volcanic rocks; and then succeed extensive districts of horizontal strata of the freshwater and marine tertiary deposits, as far as the Dardanelles, Sea of Marmora, and Constantinople, with an occasional protrusion of the trap here and here in the northern part of the Troad.

Connected with these jets of trap, between the Gulf of Smyrna and the Troad, outlying from the great centres of eruption, is an interesting point which I observed many years ago when examining and surveying the topography of the plain of Troy, to illustrate the Homeric history, and when I was accompanied by my learned friend Dr. Forchhammer of Kiel, who wrote an account of our trip for the 'Geological Journal.' Several masses of basaltic rocks peep through the tertiary strata forming the hills surrounding the plain of Troy;

but one of particular interest occurs at the site of Troy, where a ridge of volcanic rocks extends from the base of the Pergamus to the north-east of the village of Bounarbashi. The limestone-ridge, forming the Pergamus of Troy above it, and extending also to the ridges west of the village, indicates the effect of this volcanic outburst in the fissured condition of some portion of the mountain. But I refer particularly to the fact that the most copious and the most western of the springs which form the Scamander issues through two crevices or rents in a mass of red tufaceous rock that seems to be derived from and connected with these volcanic ejections. These two springs are the most copious of the whole at Bounarbashi, and together are capable of turning a water-mill after being collected in a basin at the mouth of the fissures.

These sources, coming through an apparent volcanic vent or rent, suggest most strongly that the water issuing from them in the Homeric time might then have been warmer by a connexion with the subterranean heat, although all the springs showed only 63° by the thermometer which I used in 1838. How beautifully, then, does Homer's description, as rendered by Pope, apply to the long-disputed question of the hot and cold springs of the Scamander!—

> "This, hot, through scorching clefts is seen to rise," &c.
>
> *Iliad*, xxii.

Curious and interesting, then, is this explanation of a long-doubted point of the Homeric description; and I introduce it here, not being aware that it has been noticed by any traveller since my reflections on it in 1838, as a point of geological interest in connexion with the igneous eruption above alluded to.

As the presence or absence of the above-mentioned great igneous centres have a marked influence upon the features of the country, I shall here notice that, excepting some trap-rocks, accompanied by slight local disturbances, as at Kefez Point, near the Arenkeui hospital and Chanak castle, none other occurs between the Artake Islands, in the Sea of Marmora, and Tenedos.

This district presents a great development of freshwater marls and limestones, nearly horizontal, and extending from the Troad to Lampsaki on the south side of the Dardanelles, and from Cape Hellas nearly to Rodosto on the north side, and from Rodosto to Constantinople, on the northern shore of the Sea of Marmora.

The strait of the Dardanelles entirely divides this great field of freshwater deposits, that have been apparently lifted in mass almost vertically, but divided asunder by the strait, as if separated by a great chasm; for steep cliffs or banks terminate the ridges that line both shores of the strait, in some cases displaying these deposits in a series of horizontal strata of grey and green marls, brown sands and sandstone, fully 700 or 800 feet thick.

As I never met with any marine fossils above the freshwater deposits of the Dardanelles, it appears that they were elevated above the newer Pliocene sea-level.

The localities* at which I have found freshwater fossils, in proof of my arguments, are as follows:—Cape Hellas, where the marls and sandstones contain *Cyrena* or *Cyclas*; under Yenisher, on the Asiatic side, I have found cast of *Uniones* and *Cyrenæ*? in the neighbourhood of Arenkeui†; over Nagara Point, *Unio* and a ribbed bivalve (*Cardium*) similar to that in Tenedos, with *Paludina* and *Planorbis*; the same at Meitos with fossil leaves and other plant-remains. Also *Unio* and a *Melanopsis* similar to that in Tenedos are to be obtained in great abundance in a bed of sandy marl over Kiled Bahar, the European castle of the Dardanelles.

[In a letter to the Assistant Secretary, dated June 12, 1857, Capt. Spratt states:—

"In a walk up to the village of Arenkeui, over the site of our hospital, I found the deposits to be precisely similar to those on the north side of the Dardanelles, and to consist of thick-bedded yellowish-brown sands and sandy marls, with an occasional stratum of sandstone. Towards the top, they pass into peaty marls, marlstone, and fine sands, brown, red, or cream-coloured. The fossils occur at different elevations, and comprise both the *Cyrena*? and *Melanopsis* which occur at Tenedos and Baljik.

"The fossil teeth, found by Mr. Calvert, were taken from the lower part of the group of sandy marl immediately below the village."]

The following is a section across the Dardanelles, from the hill over

* The specimens sent by Capt. Spratt from the Dardanelles and Sea of Marmora comprise—1. Blue sandy clay with *Corbulæ* (?), Cape Hellas, entrance of Dardanelles; 2. yellowish earthy limestone, mainly composed of fine shell-grit, with plant-remains (like a portion of a leaf-scarred trunk), and *Unio* and *Paludina*, from the European side of the Dardanelles; 3. hard, grey, earthy limestone, full of *Cypridæ*, *Paludina*, *Unio*, and fluted *Cardium* (*Adacna*), from the European side of the Dardanelles; 4. soft yellowish limestone, with *Adacna*,—hard ferruginous, laminated sandstone, with *Adacna*, *Cyrena* (?), *Unio*, *Melanopsis*, opercula of small *Paludinæ*, and *Cypridæ*,—and soft buff shell-grit with *Cypridæ*, from Nagara Point; 5. buff-coloured shell-grit, with harder crystalline seams, containing *Melania* and *Nerita*, from Genokora Point, entrance to the Sea of Marmora; 6. white crystalline limestone with *Cyrena*, and subcrystalline, porous, and marly white limestone, containing casts of small bivalves and *Melanopsis*, and shells of *Neritina* retaining colour, from near Cape Stephano, Sea of Marmora; 7. from Ereke, Sea of Marmora, olive-green, irregularly laminated, micaceous sandstone, with dicotyledonous leaves and fragments of plants; 8. from Marmora Island, white quartzite (rounded fragments), whitish-grey syenite (waterworn fragments), and two varieties of mica-schist; 9. from Kutali, Sea of Marmora, pinkish-grey syenite.—Edit.

† Similar fossils, with numerous fossil bones, have been obtained by our Consul, Mr. Calvert; but I have not seen them, and I am informed that the Medical Staff and the Architect of the Arenkeui hospital have taken to England some of these Mammalian remains.—T. S.

Mr. Calvert, the brother of the Consul, has obliged the Assistant Secretary with the following particulars relating to these fossil bones. The sides of a ravine or valley between Arenkeui and where the Hospital was, and running down to the sea, are formed of horizontal beds of sand and sandstone; in the former a portion of an elephantine jaw, with two teeth in place, was found; and on the higher ground, about 3 miles from the edge of the valley, some fragments of fossil ivory were found near the surface. The bottom of the valley appeared to be formed of sandstone *débris*, covering blue clay and red marl.—Edit.

Meitos to Nagara Point, through an isolated tabular mass of conglomerate, which here caps the freshwater marls at an elevation of about 100 feet above the sea, but contains no fossils.

Fig. 3.—*Section across the Dardanelles.*

a. A conglomerate of rounded pebbles of limestones, schists, and shales, similar to rocks which occur near Lampsaki.

b. Marls and sands, containing freshwater fossils. (500 feet thick on the west side of the Dardanelles.)

This conglomerate, *a*, contains no fossils like those of the mass of similar conglomerate, 70 or 80 feet thick, which forms the Promontory of Gallipoli; the latter I have before noticed* as containing fragments of a large *Dreissena* and a *Cardium*, as well as being capped by a thin stratum of sandy marl, in which these fossils occur more abundantly, both entire and broken.

The south shore of the entrance to the Sea of Marmora, from Lampsaki to Cape Karabournou, opposite Kutali Island, and around to the mouth of the Granicus, is composed chiefly of steep ridges of older rocks (limestones and shales), with volcanic protrusions, and detached fragments of the Tertiary deposits.

The north shore from Gallipoli is composed of marls and sands, which seem to be identical with the freshwater series; and at Ganakhora, opposite to Marmora Island, about 50 feet of the marly deposits are capped by a bed of conglomerate, formed of rolled pebbles, with broken shells of *Dreissena* and *Cardium*, as at Gallipoli.

In a hasty visit to Erekli and Scliori, to determine the proper sites for lighthouses on that shore, I observed the same marly and sandy deposits; and amongst the ruins at the former locality, I found that some of the ancient buildings had been built of a concreted mass of bivalves like large *Dreissenæ*; I could not learn from whence it came, but I think Rodosto.

I could find no shells in the sandstones and marls at Scliori to indicate positively its freshwater origin; but I procured some fossil leaves, which were abundant near the upper part of the cliff to the east of the town. All along this shore, the Tertiary deposits have frequently a dip from 5° to 15°, but with no constant direction.

At Bujuk Tchekmejeh the marly cliffs contain a bed of lignite, with casts of freshwater shells in the associated marls. Cape Stephano is composed of white and yellow marls, about 25 feet thick, in some parts chalky and calcareous, with irregular nodules and concretions. I was doubtful whether this was not an early and lower member of

* Quart. Journ. Geol. Soc. vol. xiii. p. 82.

the freshwater series; but, as the quarries of Makri Keui not far distant are in a white lacustrine limestone, as Mr. Strickland long ago pointed out, I am inclined to consider the Stephano marls as freshwater also, since I have found no evidence of any marine tertiary in the shores of the Sea of Marmora. In some specimens which I procured from the quarries of Makri Keui are casts of a *Melania*, apparently resembling the one I procured from the neighbourhood of Vourla in the Gulf of Smyrna, figured in the 'Geological Journal,' vol. i. p. 163.

The above evidences of the freshwater origin of the deposits which line the north shore of the Sea of Marmora seem to justify my view of connecting the basin of the Sea of Marmora and the Archipelago, as having been a part of one great lake, which probably covered a great portion of the central part of Asia Minor, as shown by Hamilton and Tchihatcheff, penetrating by the valley of the Hermes and the other valleys separating the older chains and ranges, as Xanthus on the south, the Halys on the north, and the Hermes on the west.

The lignite-beds, briefly noticed by Mr. Poole*, in the Nikomedian and Brusa valleys, are, I think, a portion of the same lacustrine series, which seems to represent a long portion of the middle and later Tertiary periods; although the relative age is difficult to determine precisely, on account of the great permanency of genera and species of the air-breathing Mollusca peculiar to the freshwater fauna.

As the two basins of the Archipelago have each their central, but extinct, volcanos, or foci of eruption, in Santorin and Lemnos, so the Sea of Marmora has its focus in Pacha Liman and the Kutali Islands, which both seem to have been volcanos, from being entirely composed of granitic trap, and presenting a crater-like form. It is also an interesting fact, that, as there is very deep water in the neighbourhood of these sudden uplifts of igneous rocks, or abrupt uprisings of the bottom (as also occurs near Micero and Methana, two other evident volcanos of no very early date), so there is in the centre of the Sea of Marmora a sudden depth of 300 and 400 fathoms (representing, perhaps, a downcast proportionate to some neighbouring great uplift of the strata); and Marmora Island in its south-western half shows a large mass of granitic and porphyritic trap, associated with crystalline limestones and micaceous shales and schists that resemble rocks of the earliest age.

The section, fig. 4, p. 213, taken along the coast, and touching at several spots, tends to confirm these views.

The marble-quarries of Marmora are celebrated; and I found them as extensive as the Pentelic Quarries of Attica, with the marble, in some parts, quite as white, pure, and crystalline as the Parian, but generally more resembling the cippoline of Carysto.

As this condition occurs only when a volcanic dyke of the porphyritic trap comes in proximity with the limestone, as seen in the section, it seems to show that these rocks owe the oldness of their aspect to their metamorphic condition; and I am inclined to think that the eruption of igneous matter in contact with them may be of

* Quart. Journ. Geol. Soc. vol. xii. p. 1.

as late a period as that of Lemnos and the other volcanic centres which have torn up the bed of the lacustrine basin, because I observed the summit of one of the highest ridges of Marmora to be capped by horizontal beds of what appeared through the glass to be red and brown marls and gravels.

These fragmentary remarks on the Dardanelles and Sea of Marmora, made for the most part during the commencement of the late war, although incomplete, will serve to call the attention of geologists to the interesting field of inquiry as to the boundaries and age of this great Oriental (if not also, in part, Mediterranean) lake or chain of lakes, as (it seems to me) indicated by detached freshwater deposits along the ancient margins.

November 4, 1857.

Robert White, Esq., West Cowes, was elected a Fellow.

The following communications were read:—

1. *On the* Triassic *and* Permian Rocks *of the* Odenwald, *in the Vicinity of* Heidelberg, *and the* Corresponding Formations *in* Central England. By Edward Hull, Esq., A.B., F.G.S.

The resemblances and general relations of the Trias and Permian formations of the Thüringerwald and Hartz, with their representatives in England, have already been pointed out in the joint memoir of Sir R. I. Murchison and Professor Morris*. The present communication refers to a neighbouring range of hills, destitute, it is true, of that fine assemblage of palæozoic rocks below the Permian, which have been shown to abound in the Hartz and Thüringerwald, but, in the case of the more recent formations, presenting many points of analogy with their contemporaries, both in the regions referred to, and in Central England.

It has been shown by Professors Sedgwick and King, as also by the authors of the memoir on the Hartz, that the Permian groups of Germany and this country can be strictly contemporanized, stratum for stratum. In visiting the Odenwald, it was partly my object to ascertain whether a similar parallelism might be observed in the case of the Trias. In doing so, however, occasion was taken to examine the Permian formation, which, though only sparingly represented in the Odenwald, presents those peculiar lithological characters which appear to identify it, not only with formations in the Thüringerwald and Hartz, but also with the trappoid breccias of Worcestershire.

Since the establishment of three well-defined subformations in the Bunter Sandstone of England, a notice of which I had the honour of laying before the Geological Section of the British Asso-

* Quart. Journ. Geol. Soc. vol. xi.